FIRE-FIGHTING EQUIPMENT IN COAL MINES--SELECTION, PLACEMENT, AND CARE

BY W. D. WALKER, JR., WILLIAM EATHORNE,
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INTRODUCTION

This information circular is offered to the coal-mining industry for use as a guide in selecting, placing, and caring for fire-fighting equipment in coal mines. Its purpose is to suggest minimum requirements for fire protection underground, and it is presented with the hope that it will aid in establishing adequate standards that will provide reasonable protection against underground fires in coal mines.

Potentially, a coal mine is a hazardous fire area. Coal itself is a combustible substance, easily ignited. In addition, large quantities of other combustible materials must be present in the area of operations; these include materials for roof support, track ties, doors, ventilation stoppings, lubricants, etc.

Underground fires are to be feared primarily because of the high probability of entrapping personnel, since escapeways are necessarily limited in number, and some are likely to become impassable in the event of fire.

In the presence of combustible gas or coal dust, both of which form violently explosive mixtures with air, an explosion resulting in heavy loss of life and extensive property damage can be initiated by a small fire, and, on the other hand, explosions frequently cause fires. In addition, heavy loss of life can be caused among trapped personnel by secondary effects of underground fires. These are reduction of atmospheric oxygen below the concentration necessary to sustain life and direct asphyxiation or poisoning from products of incomplete combustion, particularly carbon monoxide.

Two methods of approach to the fire problem have been adopted by fire-control authorities. One is known as fire prevention and the other as fire protection. Fire prevention is primarily concerned with precautions to prevent starting fires and, to a lesser degree, with limiting the severity of fires. Fire protection deals with extinguishing or subduing fires and includes all types of equipment, materials, and techniques used in fire fighting.

A discussion of fire-prevention measures, adequate escapeways, safety chambers, barricading, and special methods that may have to be adopted when a mine fire becomes uncontrollable is considered a subject within itself; to include these matters in this publication would detract from its intended purpose. Those interested in these subjects are referred to Bureau of Mines publications listed in appendix 2.

Fire-alarm systems are of proved worth for surface installations, but their installation and maintenance underground may be difficult. Those interested are referred to the National Fire Protection Association or other recognized authority. (See footnote 4.)

The following disastrous fires, which have occurred during recent years, are briefly described to emphasize the seriousness of a mine fire.

On January 8, 1943, at the No. 15 mine of the Pursglove Coal Mining Co., Pursglove, W. Va., 13 of the 78 men underground died as a result of a fire started by a short circuit on a main-line trolley wire. The fire developed extensively before the fire-fighting facilities (consisting of water, rock-dusting machines, and chemical fire extinguishers) could be brought to bear on it. Federal Bureau of Mines investigators disclosed the facts that the fire-fighting facilities provided were not readily available and that the fire-fighting organization was inadequately trained.

On July 5, 1944, at the Powhatan mine, Powhatan Mining Co., Powhatan Point, Ohio, 66 of the 190 men underground were trapped and died from the results of a fire that started when dislodged roof material tore down an energized trolley wire, which ignited the coal. The underground fire-fighting facilities consisted of water mains, water outlets, fire hose, two high-pressure rock-dusting machines, and soda-acid extinguishers. Considerable time elapsed before any fire-fighting equipment was brought to bear on the fire, which could not be brought under control with the facilities available at that time.

On November 4, 1948, at the Milt No. 1 mine, Nethken Coal Co., Kitzmiller, Md., 5 of the 7 men underground were trapped and died from the smoke and fumes of a fire that originated in a wooden fan house on the surface where a gasoline-driven fan was being operated. A 1-pint carbon tetrachloride fire extinguisher, which was kept in a shed nearby, proved inadequate to cope with the fire. This extinguisher represented the entire fire-fighting equipment available on the property.

A discussion of the fire-fighting facilities adopted for underground coal mines throughout the world would be a lengthy and difficult undertaking. Available information indicates that regulations and practices in foreign countries are generally sketchy and indefinite.

About half of the States where coal is mined in the United States have no fire-fighting-equipment requirements for coal mines, and most of the remaining States list these provisions in a short paragraph or two.

The Federal Mine Safety Code and the Federal Coal Mine Safety Act have the following provision in common:

> Each mine shall be provided with suitable fire-fighting equipment, adequate for the size of the mine.

The terms "suitable" and "adequate" are subject to varied individual interpretations, and endless arguments are likely to develop in the absence of a guide.

The recommendations of the National Fire Protection Association,[4] 60 Batterymarch Street, Boston, Mass., are used extensively by the Federal, State, and local Governments and by industry for establishing suitable and adequate fire-fighting equipment. These recommendations, where considered practicable, have been adopted. In addition, certain equipment and materials commonly used in coal mines have been recommended for fire fighting because they can be used successfully.

Authorities on fire fighting agree that most fires can be subdued if they are attacked early; therefore, being prepared to attack a fire while it is incipient is a key protective measure. An extremely important point to remember in fighting mine fires is to attack from the fresh-air (intake) side when men are not adequately protected with respiratory devices.

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[4] A nonprofit organization used as a clearing house for all that is authoritative on the subject of fire prevention and fire protection. Hereafter, this organization will be referred to as the N.F.P.A.

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FIRE CLASSIFICATION

It is essential that the fire classification adopted by the N.F.P.A. be thoroughly understood before an attempt is made to provide fire-fighting facilities, otherwise, fire-fighting equipment is likely to be inadequate and unsuitable. The following explains the N.F.P.A. classifications.

Class A Fires

Class A fires are defined as those in ordinary solid, combustible materials, such as coal, wood, rubber, textiles, paper, and rubbish.

Fires of these materials can be best controlled through the quenching or cooling action of water or solutions containing large proportions of water. Chemical fire extinguishers, such as soda acid, foam, and loaded stream, also can be used successfully on fires in this class. Other types of chemical fire extinguishers are somewhat limited in their effectiveness when used on class A fires. Rock dust and fine sand may be used, but in some instances, such as overhead fires, these agents are difficult to apply.

Class B Fires

Class B fires are defined as those in flammable liquids, such as fuel or lubricating oils, grease, paint, varnish, and lacquer.

Blanketing or smothering is essential for fighting this class of fire successfully. Chemical fire extinguishers, such as foam, dry chemical, liquid carbon dioxide, vaporizing liquid, and loaded stream, are suitable for class B fires. Rock dust or fine sand may be used also. In no case should water be used unless a "spray," "mist," or "fog" nozzle is provided. Class B fires are considered by fire-fighting authorities to be the most difficult to control; they are likely to spread rapidly.

Class C Fires

Class C fires are defined as those in (live) electrical equipment, such as oil-filled transformers, generators, motors, switch panels, circuit breakers, insulated electrical conductors, and other electrical devices. A nonconducting extinguishing agent is essential for fighting fires of this class.

Chemical fire extinguishers, such as liquid carbon dioxide, dry chemical, and vaporizing liquid, are suitable for fires in this class. Rock dust or fine sand may be used also, but either of these - the latter in particular - may damage electrical equipment.

When the electric circuit has been deenergized, the nonconducting recommendation previously mentioned may be ignored. However, when planning fire-fighting facilities for class C fire hazards this exception should not be given weight. Where electricity is involved in a fire, it is advisable to deenergize the circuit as soon as possible, because, under certain conditions, a fire cannot be extinguished when a live circuit exists at the seat of the fire.

Identification of Fire-Fighting Facilities

Every fire-fighting facility provided should be plainly marked so that its proper application to each class of fire can be readily determined. For example: A facility suitable only for class A fires should be plainly marked with a large letter A; class B with a large letter B; and class C with a large letter C. Facilities suitable to more than one class of fire should be marked with the proper combination of letters, as A-B or B-C.

GROUPING OF MINES

In establishing a fire-fighting program for a coal mine, the following points should be considered:

a. The number of men employed underground.

b. The daily production of the mine.

c. The area of the mine.

The number of men employed underground is indicative of the number who may be exposed to danger from a fire, and the production and concentration of equipment have a bearing on the number of men employed in a given area. Therefore, these factors are given considerable weight.

The area of a mine should not be given equal weight with the foregoing, because the area of a mine does not necessarily relate to the number of men employed or the production. Therefore, mines are grouped here according to the number of underground employees or the tonnage produced in 24 hours.

Group 1

Three hundred men or more or 2,000 tons or more.

Group 2

Between 50 and 300 men or between 300 and 2,000 tons.

Group 3

Less than 50 men or less than 300 tons.

SELECTION OF FIRE-FIGHTING FACILITIES ACCORDING TO GROUP SIZE

The following fire-fighting facilities should be considered the minimum requirements in mines according to group size:

Group 1 Mines

a. Water lines, hydrants or hose taps, fire hose, and nozzles.

b. Truck-mounted water or chemical tanks, high-pressure rock-dusting machines.

c. Hand-type fire extinguishers, barrels of water with pails, rock dust or sand.

d. Miscellaneous fire-fighting materials and tools.

Group 2 Mines

a. Truck-mounted water or chemical tanks, high-pressure rock-dusting machines. (There is no objection to substituting (a) under group 1 mines for this provision.)

b. Hand-type fire extinguishers, barrels of water with pails, rock dust, or sand.

c. Miscellaneous fire-fighting materials and tools.

Group 3 Mines

a. Hand-type fire extinguishers, barrels of water with pails, rock dust, or sand.

b. Miscellaneous fire-fighting materials and tools.

A group 1 mine that is wet enough naturally to reduce class A fire hazards may adopt truck-mounted water or chemical-tank requirements outlined for a group 2 mine in place of the water-line provisions. The substitution may cover the mine in its entirety or in part.

A group 1 mine that has water lines at the working areas but not elsewhere may adopt the truck-mounted water or chemical tank requirements outlined for a group 2 mine provided that twice the fire-fighting equipment recommended for a group 2 mine is made available.

A group 1 mine remote from a water supply, or where a water supply is not reasonably available, may adopt the truck-mounted water or chemical-tank requirements outlined for a group 2 mine, provided that twice the fire-fighting equipment recommended for a group 2 mine is made available.

PLACEMENT OF FIRE-FIGHTING FACILITIES

Water Lines

Water lines should be available at the top and bottom of a main shaft or slope or at the mine portal and should extend along the main and secondary haulageways to all working sections of the mine. Water-pump lines that keep the mine free of water accumulations may be substituted for other water-line facilities provided they are fitted with outlets for fire-hose connections. Compressed-air lines may be substituted for a water-line facility provided they are interconnected to water lines and suitable valve controls are attached to permit the use of air lines as water lines. Water lines for fighting fire should be at least 2 inches in diameter, and the reserve water supply should be at least 5,000 gallons. The pressure should be enough to permit a nozzle discharge of 50 gallons of water a minute.

Water lines should be installed so as not to obstruct required clearance.

Hydrants or Hose Taps

The following suggestions pertaining to hydrants or hose taps and fire hose are based on the use of cotton rubber-lined hose. If linen hose or its equivalent in frictional loss is used, such distances or lengths should be reduced by one-half.

Where water lines are installed, hydrants or hose taps should be provided within 500 feet of the top and bottom of a main shaft or slope, or main portal, and every working face. Also, they should be available at intervals not exceeding 500 feet along main and secondary haulageways.

They should be installed so as not to obstruct required clearance, protected against damage, easily accessible, in full view, and conspicuously marked.

All hydrants or hose taps should be provided with thread protection.

The flowing water pressure at a hydrant or hose tap should not exceed 120 p.s.i.; pressure-reducing valves should be provided at the outlets to avoid bursting a fire hose where higher flow pressures prevail.

Fire Hose and Nozzles

Where hydrants and hose taps are installed, fire-hose stations containing not less than 500 feet of hose should be within 500 feet of the top and bottom of a main shaft or slope or mine portal and in each working section. Also, they should be at intervals not exceeding 5,000 feet along main and secondary haulageways.

Fire hose should be at least 1-1/2 inches in diameter and be fitted with a standard thread connection that will fit any other hose, hydrant, or hose tap in the mine.

Fire-hose stations should be in dry and reasonably safe places and not obstruct required clearance. They should be conspicuous and plainly marked.

The fire hose at a station should be stored on a hose reel or rack or in a cabinet.

A fire-hose nozzle, minimum size 1/2 inch, should be provided at each hose station and may be prefitted to one of the hose lengths.

Truck-Mounted Water or Chemical Tanks When Used in Conjunction With Water Lines in Group 1 Mines

Secondary fire-fighting equipment is advisable where water lines are available because the water-line system may be rendered useless by a derailment or a fall of roof. Furthermore, a disruption at the source of the water supply or pump failure might occur at a critical time, or a fire might occur at some point remote from the water line.

Each truck-mounted water-tank unit designed to serve as a secondary means for fire fighting should have a 500-gallon minimum capacity and at least 200 feet of 1-1/2-inch fire hose fitted with a 1/2-inch nozzle.

Each truck-mounted water tank should be equipped with a pump to maintain enough water pressure to deliver a minimum of 50 gallons of water a minute when using 200 feet of 1-1/2-inch hose fitted with a 1/2-inch nozzle.

A truck-mounted water-tank unit should be stationed within 500 feet of a main shaft or slope, or mine portal, and within 5,000 feet of each working section.

Truck-mounted chemical-tank units may be substituted for truck-mounted water-tank units provided they are of equal value for fire fighting.

Truck-Mounted Water or Chemical Tanks When Used As Primary Fire-Fighting Equipment in Group 2 Mines

Where truck-mounted water-tank units are adopted as a primary means of fire fighting in group 2 mines, each unit should have a minimum capacity of 1,000 gallons. The water-pressure, delivery, fire-hose, and nozzle specifications should conform to the group 1 mine recommendations for this type of equipment.

Truck-mounted water-tank units should be stationed within 500 feet of a main shaft or slope, or mine portal, within 2,500 feet of a working area, and at intervals not exceeding 5,000 feet along main and secondary haulageways.

Truck-mounted chemical-tank units may be substituted for truck-mounted water-tank units, provided they are of equal value for fire fighting.

High-Pressure Rock-Dusting Machines

A high-pressure rock-dusting machine may be substituted for any truck-mounted fire-fighting unit previously described, provided it is fitted with at least 250 feet of hose and is kept close to the area to be protected. This substitution should be limited to 50 percent of the total mine requirement for truck-mounted facilities.

At least 60 sacks of rock dust, in good condition, should be available at or near the rock-dusting machine at all times if it is to serve as an established piece of fire-fighting equipment.

A mixture of 65 percent rock dust and 35 percent water, by weight, is more efficient than dry rock dust when applied to mine fires, but special attachments are needed to apply it.5/

Hand-Type Fire Extinguishers

In every mine, hand-type fire-fighting facilities of suitable type should be readily available near the following locations to extinguish fire in its incipiency:

a. Electrically operated equipment.

b. Lubricant storage of over 10 gallons.

c. Welding equipment.

d. Wooden ventilation doors.

e. Working faces.

In the following recommendations for hand-type fire-fighting facilities, an optional choice is given within suitability standards. (See suitability and efficiency ratings in appendix 1.) The minimum size of any extinguisher listed does not preclude the use of its equivalent in smaller sizes, provided the combined capacity is not under that recommended.

5/ See under report of investigations in appendix 2.

Electrically Operated Equipment

Any of the following electrically operated equipment should be provided with a hand-type fire extinguisher suitable for a class C fire, the minimum size of the extinguisher being as specified hereafter:

Stationary Units

- Transformers, oil-filled
- Circuit breakers, oil-filled
- Generators, converters, or rectifiers
- Pumps
- Fans
- Hoists
- Compressors
- Belt-conveyor drives
- Battery chargers
- Shop equipment

Mobile or Portable Units

- Locomotives
- Continuous mining machines
- Cutting machines
- Drilling machines
- Electric drills, portable
- Loading machines
- Timber machines
- Shuttle cars
- Compressors
- Rock-dusting machines
- Portable pumps
- Post pullers

Transformers, oil-filled - 15 kv.-a. and under

Liquid carbon dioxide	5-pound
Dry chemical	4-pound
Carbon tetrachloride	*2-quart

Transformers, oil-filled - over 15 kv.-a. and up to 50 kv.-a.

Liquid carbon dioxide	10-pound
Dry chemical	10-pound
Carbon tetrachloride	*1-gallon

Transformers, oil-filled - over 50 kv.-a.

Liquid carbon dioxide	20-pound
Dry chemical	20-pound
Carbon tetrachloride	*2-gallon

Circuit breakers, oil-filled - 500 amperes or under

Liquid carbon dioxide	5-pound
Dry chemical	4-pound
Carbon tetrachloride	*2-quart

Circuit breakers, oil-filled - over 500 amperes

Liquid carbon dioxide	10-pound
Dry chemical	10-pound
Carbon tetrachloride	*1-gallon

Generators, converters, or rectifiers - 100 kw. or under

Liquid carbon dioxide	10-pound
Dry chemical	10-pound
Carbon tetrachloride	*1-gallon

Generators, converters, or rectifiers - over 100 kw.

Liquid carbon dioxide	20-pound
Dry chemical	20-pound
Carbon tetrachloride	*2-gallon

Motor size - 15 hp. and under

Liquid carbon dioxide	5-pound
Dry chemical	4-pound
Carbon tetrachloride	*2-quart

Motor size - over 15 hp. and up to 50 hp.

Liquid carbon dioxide	10-pound
Dry chemical	10-pound
Carbon tetrachloride	*1-gallon

Motor size - over 50 hp.

Liquid carbon dioxide	20-pound
Dry chemical	20-pound
Carbon tetrachloride	*2-gallon

* The toxic hazards of carbon tetrachloride when it is used on a fire are explained under Carbon Tetrachloride on page 15.

All hand-type fire extinguishers used for mobile electrical equipment should be carried on the equipment or distributed throughout a working section so that an extinguisher of the proper size is within 150 feet of the point where equipment is being operated.

All hand-type fire extinguishers used for portable (hand-moved) electrical equipment should be within 150 feet of where the equipment is being operated.

All hand-type fire extinguishers used for stationary electrical equipment in enclosures should be placed on the outside of the enclosure near the entrance and be conspicuously marked.

Where two or more pieces of stationary electrical equipment are combined to form a unit, the fire-fighting equipment provided for the largest component will suffice for the entire installation.

Lubricant Storage of Over 10 Gallons

Each underground storage of from 10 to 50 gallons of lubricants should be protected with one of the following hand-type extinguishers:

Foam	2-1/2-gallon
Loaded stream	1-3/4-gallon (2 units)
Liquid carbon dioxide	15-pound
Dry chemical	15-pound
Rock dust	240 pounds

When storing over 50 gallons of lubricants, an additional extinguisher of equivalent capacity should be provided for each additional 50 gallons or part thereof.

The extinguisher or the rock dust should be located near and outside the storage entrance.

Welding Equipment

Each piece of welding equipment, irrespective of type, should be provided with one of the following fire-fighting facilities:

Liquid carbon dioxide	10-pound
Dry chemical	10-pound

At least three sacks of rock dust should be readily available to augment the foregoing where class A fire protection is not readily available.

Wooden Ventilation Doors

Every wooden ventilation door should have within 50 feet of its location one of the following fire-fighting facilities, and the facility should be conspicuously marked:

Pump tank (water)	2-1/2-gallon
Gas pressure (water)	2-1/2-gallon
Soda acid	2-1/2-gallon
Foam	2-1/2-gallon
Loaded stream	1-3/4-gallon
Rock dust	240 pounds
Barrel of water and 3 pails.	

Working Faces

Where water is not piped to the faces of working places, one unit of the following hand-type fire-fighting facilities should be available within 200 feet of each working face and should be conspicuously marked:

Pump tank (water)	2-1/2-gallon
Gas pressure (water)	2-1/2-gallon
Soda acid	2-1/2-gallon
Foam	2-1/2-gallon
Loaded stream	1-3/4-gallon
Rock dust	240 pounds
Barrel of water and 3 pails.	

One unit may serve for more than 1 working face provided it is within the 200-foot limit, or 3 units may be assembled at 1 location provided the faces afforded protection are within a distance of 600 feet.

Miscellaneous Fire-Fighting Materials and Tools

In every mine, storage of miscellaneous fire-fighting materials and tools should be established within 500 feet of a main shaft or slope or mine portal and within 5,000 feet of any working face.

Every storage should contain an adequate supply of rock dust, boards, brattice cloth, shovels, picks, saws, bars, nails, and concrete blocks or their equivalent. These may be preloaded to facilitate transportation. The storage should be established in a safe area, conspicuously marked, easily accessible, and free of obstructions that might interfere with speedy removal of materials or tools.

SELECTION AND PLACEMENT OF FIRE-FIGHTING FACILITIES AT SPECIAL INSTALLATIONS

a. Underground stables.

b. Shops - battery-charging stations.

c. Belt conveyors.

Underground Stables

Every underground stable should be provided with a water line fitted with a hydrant or hose tap near the entrance and fire hose fitted with a 1/2-inch nozzle. The hose should be long enough to reach the entire length of the stable and have a minimum diameter of 1-1/2 inches. A 500-gallon truck-mounted water tank may substitute for the foregoing provision if it is stored near the entrance and provided with 200 feet of 1-1/2-inch fire hose fitted with a 1/2-inch nozzle.

Every stable should also be provided with one of the following hand-type fire extinguishers for each 2,000 square feet of floor space or part thereof, the minimum size of the extinguisher adopted being as specified:

Pump tank (water)......................	2-1/2-gallon
Gas pressure (water)...................	2-1/2-gallon
Soda acid..............................	2-1/2-gallon
Foam...................................	2-1/2-gallon
Loaded stream..........................	1-3/4-gallon
Barrel of water and 3 pails.	

At least three sacks of rock dust should be readily available to augment each extinguisher.

Where the stable area is 2,000 square feet or less, the facilities should be placed near the entrance, but where the area is over 2,000 square feet the facilities should be placed at reasonable intervals within the stable. The facilities should be conspicuously marked.

Shops - Battery-Charging Stations

Every underground shop or battery-charging station having an area of 2,000 square feet or more should be provided with water for fire fighting, as outlined for underground stables; shops of smaller area should be provided with a 50-gallon barrel of water and 3 fire pails or equivalent facilities for a class A fire.

Every shop or battery-charging station should also be provided with hand-type fire extinguishers suitable for class B and class C fire hazards, the minimum size of the extinguisher adopted being as specified:

Liquid carbon dioxide - 20 pounds for each 2,000 square feet of space or part thereof

Dry chemical - 20 pounds for each 2,000 square feet of floor space or part thereof

At least 6 sacks of rock dust for each 2,000 square feet of floor space or part thereof should be readily available to augment the chemical fire extinguishers.

Where the shop or battery-charging station area is 2,000 square feet or less, the facilities should be placed near the entrance, but where the area is over 2,000 square feet the facilities should be placed at reasonable intervals within the shop or station. The facilities should be conspicuously marked.

Belt Conveyors

In every mine where belt conveyors serve in the haulage system, the main and gathering belts should be provided with (1) water lines, hydrants or hose taps, fire hose, and nozzles or (2) a sprinkler system installed in accordance with the specifications of the N.F.P.A.

(1) Water lines, hydrants or hose taps, fire hose, and nozzles

When a water line, hydrant or hose taps, fire hose, and nozzles are adopted, the water line should extend from end to end of the belt system. The line should be large enough to permit the flow of two 50-gallon-a-minute streams simultaneously when using two 250-foot lengths of 1-1/2-inch fire hose fitted with 1/2-inch nozzles.

The hydrants or hose taps should be provided at the intake-air side within 250 feet of the drives, transfer points, and tailpieces and at intervals not exceeding 250 feet along the belt system.

At least 250 feet of 1-1/2-inch fire hose equipped with a 1/2-inch nozzle, regular or adjustable water spray, mist, or fog (so-called fog nozzle), should be provided and stored within easy reach of every 4 hydrants or hose taps.

(2) Sprinkler system

Sprinkler systems, automatic or manually operated, are efficient devices for controlling fires at surface operations; however, their installation, application, and care for effective operation are complicated. A few of the difficulties that may be encountered when adopting such installations in a mine are:

(a) Cooling effect of air currents on heat-responsive devices.

(b) Proper installation of sprinkler heads may be difficult due to irregularities of the roof.

(c) Installation of large pipe lines to insure ample water for all sprinkler heads when operating simultaneously.

(d) Maintenance.

For these reasons, standards for such installations have not been formulated. If a sprinkler system is desired, it will be advisable to obtain the services of a competent fire-protection engineer or other person well informed on such installations.

Substitution for Waterline or Sprinkler Systems

When nonflammable belting of proved worth is used, the foregoing recommendations for waterline or sprinkler facilities may be disregarded if one of the following hand-type fire extinguishers is made available at intervals not exceeding 300 feet along the belt:

Pump tank (water)	2-1/2-gallon
Gas pressure (water)	2-1/2-gallon
Soda acid	2-1/2-gallon
Foam	2-1/2-gallon
Loaded stream	1-3/4-gallon
Barrel of water and 3 pails.	

Three sacks of rock dust may be substituted for a hand-type extinguisher at alternate locations.

Hand-Type Fire-Fighting Facilities for Electrical Fires at Belt Conveyors

Although belt-conveyor drives come under the recommendations previously made for electrical installations, it is believed that this issue should be further discussed because of the extra-hazardous fire problem involved.

The hand-type fire extinguishers adopted at any of the electrical equipment actuating a belt-conveyor system should be stored not more than 50 feet away from the electrical installation and on the intake-air side. Cabinets should be provided for storing the extinguishers, and they should be conspicuously marked. At least 6 sacks of rock dust and 2 shovels should be readily available to augment each extinguisher.

CARE OF FIRE-FIGHTING FACILITIES

The care of fire-fighting facilities is extremely important, because a defective facility will be a means for falling below what is believed to be a minimum standard for fire protection in a mine. This essential is likely to be overlooked, since such equipment is used infrequently.

The following are minimum precautions that should be taken; however, in a mine or section of a mine where atmospheric or other conditions are unusually poor, more stringent precautions may be advisable.

Waterlines, Hydrants or Hose Taps, Fire Hose, and Nozzles

Leaks in a waterline, hydrant, or hose tap should be promptly repaired. Protection against freezing for the foregoing should be provided where necessary, and pressure gages should be installed or available for checking the water pressure frequently at strategically located hydrants or hose taps.

All hydrants or hose taps should be flushed once every 3 months.

Cotton rubber-lined hose is the standard fire-department hose for general outside use in the United States and Canada. It is available with single, double, or triple jackets treated to withstand mildew and repel water. Water should be passed through this type of hose at least four times a year to keep the rubber lining in good condition.

Unlined linen hose is primarily used for short lines inside of buildings because it is not affected by ordinary room temperatures and because it is light weight, compact, and easily managed by one person. However, holes quickly chafe through when it is laid over sharp-edged or abrasive materials or around corners. It will rot or mildew if left even slightly damp in storage, and for this reason it is not ordinarily water-tested. Visual inspection should be relied upon to determine if the hose is satisfactory.

The principal sources of damage to fire hose are mechanical injury, heat, mildew and mold, acid solutions, gasoline, and oils. Tears, snags, and abrasions may develop if care is not taken to avoid dragging hose over rough surfaces or protruding spikes, nails, or sharp switch points. Every precaution should be taken to keep these damaging hazards at a minimum.

Fire hose stored on reels, racks, or in cabinets should be stretched out once every 3 months to change the folds and prevent kinks from being in a set position too long. All hose should be thoroughly dried after every use.

Truck-Mounted Water or Chemical Tanks

Truck-mounted water or chemical tanks should be maintained in good mechanical condition at all times.

Immediately after use, water-tank units should be refilled and chemical tank units should be recharged.

All tank units, water or chemical, should be flushed and recharged once every 6 months.

Precautions for the care of hose stored on any tank unit should conform to the recommendations previously made for the care of fire hose.

High-Pressure Rock-Dusting Machines

Because of the frequent use of high-pressure rock-dusting machines in mines, this equipment is more likely to be kept in operating condition than any other facility adopted for fire fighting. However, any defects noticed, minor or otherwise, should be repaired immediately.

Hand-Type Fire Extinguishers

Most incipient fires can be extinguished or subdued by prompt use of suitable hand-type fire-fighting facilities, and recommendations for the proper care of such facilities should be rigidly carried out. The N.F.P.A. recommends that damaged extinguishers should be repaired only by the manufacturer.

Pump Tank

Clean water reasonably free from acids or alkalies should be used for charging, and the extinguisher should be discharged once every 6 months. It should be recharged immediately after use. Freeze protection may be provided by adding a designated amount of specially prepared calcium chloride to the water charge.

Gas Pressure

Clean water reasonably free from acids or alkalies should be used for charging. The carbon dioxide cartridge used for expelling the water should be recharged by the manufacturer. Once every 6 months the extinguisher should be discharged. It should be recharged immediately after use. Freeze protection may be provided by adding a designated amount of specially prepared calcium chloride to the water charge.

Loaded Stream

Charge according to the manufacturer's instructions. A supply of the alkali-metal salt solution used in this extinguisher should be kept on hand for recharging.

Spare carbon dioxide cartridges used as an expelling medium should also be kept on hand. Recharge after use. The alkali-metal salt solution does not deteriorate; therefore, periodical discharging is unnecessary. However, the pressure cartridge should be checked by weighing once every 6 months. Freeze protection is unnecessary.

Soda Acid

Clean water reasonably free from acids and alkalies should be used for the water charge. Charge according to the manufacturer's instructions. Once every 6 months the extinguisher should be discharged. Recharge after use. A hydrostatic test should be made every 5 years. The only satisfactory freeze protection for this type of extinguisher is a heated cabinet.

Foam

Clean water reasonably free from acids and alkalies should be used in making up a charge. Charge according to the manufacturer's instructions. Once every 6 months, the extinguisher should be discharged. Recharge after use. A hydrostatic test should be made once every 5 years. The only satisfactory freeze protection for this type of extinguisher is a heated cabinet.

Liquid Carbon Dioxide

The extinguisher should be charged by the manufacturer or a reputable firm that specializes in charging this type of extinguisher. Once every 6 months, the contents should be checked by weighing. Recharge after use. A hydrostatic test is necessary every 5 years. Freeze protection is not necessary.

Dry Chemical

The dry chemical (powder) used in this type of extinguisher should be as specified by the manufacturer. In types using a pressure cartridge for expelling the powder, the pressure cartridge should be checked by weighing every 6 months. Types fitted with a built-in pressure gage to indicate the pressure charge may be checked by observation. Once every 6 months, this type of extinguisher should be turned upside down and shaken gently to loosen the powder charge. Freeze protection is not necessary.

Carbon Tetrachloride

Commercial carbon tetrachloride is unsatisfactory for use in a fire extinguisher; the charge, therefore, should conform to the manufacturer's specification. Expel the fluid every 6 months; if clear it may be used again, if not clear do not use again. Freeze protection is not necessary when this extinguisher is charged with the manufacturer's prepared product.

A carbon tetrachloride fire extinguisher should be used with extreme care in confined spaces where there is little air movement. The operator must be careful not to breathe carbon tetrachloride, hydrochloric acid, chlorine, or phosgene vapors. ALL OF THESE VAPORS ARE VERY DANGEROUS.

Since there is some likelihood that on underground fires the extinguisher might be used in confined places or in the return-air side, it is not recommended, and any of them in use should be removed as expediently as practicable through a program of replacement with liquid carbon dioxide or dry chemical types.

Barrels of Water With Fire Pails

When barrels of water are established as a fire-fighting facility, they should be located in safe places, not obstruct the clearance, and be kept full of water. Three 12-quart fire pails should be hung on brackets attached to the barrel or stored on a shelf erected over the barrel. The fire pails should not be used for any purpose other than fire fighting. Dome-bottom pails will help to prevent their use for other purposes.

Rock Dust or Sand

Rock dust or sand should be stored at locations free from dripping water or contact with wet surfaces, materials, or objects. Where the relative humidity of the atmosphere at a storage is noticeably high, a plan should be adopted for replacement at intervals that experience indicates to be desirable.

Miscellaneous Fire-Fighting Materials and Tools

Miscellaneous fire-fighting materials and tools specifically reserved for fire-fighting should not be allowed to deteriorate through lack of attention. The storage for these facilities should not be used for any other purpose. If any of the supplies in a storage are withdrawn or have deteriorated they should be replaced promptly.

INSPECTIONS, TRAINING, MAPS, AND EFFICIENCY RATINGS OF HAND-TYPE FIRE-FIGHTING FACILITIES

Details pertaining to inspections, training, maps, and efficiency ratings of hand-type fire-fighting facilities in common use will be found in appendix 1.

CONCLUSIONS

Fire-fighting requirements for numerous other industries have been developed to a high standard through many years of application. The coal industry has lagged in this respect, and the application of such facilities has been somewhat indifferent and haphazard. The first guide detailing the selection, placement, and care of facilities according to employment, production, and area of a coal mine is, therefore, subject to criticism of insufficiency on the one hand and severity on the other.

It is a well-established fact with underground fires, as with those on the surface, that measures must be applied quickly to prevent incipient fires from spreading. The record of fires in coal mines shows that in many instances facilities for combating incipient or widespread fire were very meager or lacking entirely. It would be virtually impossible to establish and maintain all the facilities that may be needed to extinguish widespread mine fires, but it is believed that the coal industry can ill afford less than the minimum required by other industries where the time element and avenues of escape are much more favorable.

This guide has been prepared to assist those in the coal-mining industry charged with the responsibility of preventing the loss of life in underground operations. It is sincerely hoped that it will be received in the spirit that it is given. REMEMBER, EVERY MINUTE COUNTS FROM THE MOMENT A FIRE STARTS, AND EVERY MINUTE WASTED MAY RESULT IN LOSS OF LIFE.

APPENDIX 1

Inspections, Training, Maps, and Efficiency Ratings of Hand-Type Fire-Fighting Facilities

Inspections

It is not likely that fire-fighting facilities will be properly maintained without an inspection service instituted by the mine management. Instances where the fire-fighting equipment available was, for various reasons, not operative or suitable when urgently needed are numerous and have resulted in loss of life.

Therefore, it is recommended that the fire-fighting facilities available be inspected once every 3 months by a qualified person who thoroughly understands every device or material that has been provided for fire protection. Any defects or shortages that may have developed since the previous inspection should be recorded and discussed with the management; corrective measures should be applied immediately.

Every hand-type fire extinguisher should carry a tag indicating when it was inspected and the inspector's initials or name. Similar tagging of all truck-mounted facilities, hose stations, and miscellaneous fire-fighting items is recommended also.

Training

A general knowledge of fire and the proper use of fire-fighting facilities by some of the mine personnel are essentials that should not be overlooked. In an underground fire, it will not be practical, or advisable in most instances, to call in trained fire brigades who are limited in experience to surface conflagrations; therefore, selected mine personnel should be educated and trained to serve as a fire brigade.

It is recommended that all supervisors and about 10 percent of the employees on every shift should be educated and trained as indicated in the following outline:

1. Have a reasonable knowledge of class A, B, and C fires as described in the guide.
2. Be familiar with all fire-fighting facilities in the mine and their locations, and be well versed in their proper use.
3. Have actual training in the use of all available fire-fighting facilities once every 6 months.

The foregoing educational program, to be effective, must be followed diligently.

Maps

A fire-fighting program is not likely to be successful without the aid of plans or maps. These should show the location, type, and size of all fire-fighting facilities, and also the escapeways marked distinctly. The maps should be kept up to date, and a copy should be posted in a room accessible to all employees or on a glass-enclosed bulletin board.

Efficiency Ratings

The comparative efficiency ratings of various hand-type fire-fighting facilities commonly used (as reported by the N.F.P.A.) are provided in the following tabulation. The letters A, B, and C indicate suitability according to fire classification, and the numbers represent the quantity needed to provide a fire-fighting unit. The absence of any letter in a rating indicates that the facility should not be used for that particular class of fire or that its efficiency is too limited to be given a rating.

A 12-quart fire pail has a rating of A-5 and a 2-1/2-gallon pump tank has a rating of A-1, indicating that it will take 5 pails of water to equal a 2-1/2-gallon pump tank on a class A fire. In the case of a 10-pound liquid carbon dioxide extinguisher, having a rating of B-2 and C-1, it will take two of these to provide a fire-fighting unit for a class B fire, but only one is needed for a class C fire; this extinguisher can be used on an A fire, but its efficiency is too limited to be given a rating for such. For example, a class A rated extinguisher, in the absence of any other letter, should not be used on a class B or C fire, but an extinguisher rated for class B and C fires may be used on a class A fire - the absence of the letter A in this case indicates that the efficiency for fighting a class A fire is limited.

Fire pail (water)....................	12-quart	A-5		
Pump tank (water)....................	2-1/2 gallons	A-1		
Gas pressure (water).................	2-1/2 gallons	A-1		
Loaded stream........................	1 gallon	A-2	B-4	
Do.	1-3/4 gallons	A-1	B-2	
Soda acid............................	1-1/2 gallons	A-2		
Do.	2-1/2 gallons	A-1		
Foam.................................	1-1/2 gallons	A-2	B-2	
Do.	2-1/2 gallons	A-1	B-1	
Liquid carbon dioxide................	5 pounds		B-2	C-2
Do.	10 pounds		B-2	C-1
Do.	15 pounds		B-1	C-1
Dry chemical.........................	4 pounds		B-2	C-2
Do.	10 pounds		B-2	C-1
Do.	15 pounds		B-1	C-1
Carbon tetrachloride.................	1 quart		*B-2	C-2
Do.	2 quarts		*B-2	C-2
Do.	1 gallon		*B-2	C-1
Do.	2 gallons		*B-2	C-1
Sand pails...........................	12-quart		*B-5	
(Use should be supplemented by other equipment.)				
Rock dust............................	Suitable for A, B, or C fires (See following note)			

Tests to determine the value of rock dust as a fire-extinguishing agent have not been extensive enough to establish a unit value in comparison with accepted standards of the N.F.P.A. Based on the information available, a reasonable value for mine use is that three 80-pound sacks be accepted as one unit for class A, B, or C fires. A shovel with a long handle will assist greatly in applying the rock dust and reduce loss through waste.

* See toxic properties of carbon tetrachloride, p. 15.

APPENDIX 2

Additional References

Additional information may be obtained from the following Bureau of Mines publications:

Bulletins

RICE, G. S., PAUL, J. W., and VON BERNEWITZ, M. W. Fifty-Nine Coal-Mine Fires; How They Were Fought and What They Teach. B. 229, 1927, 156 pp. Covers a period of 16 years. Discusses practical methods of fire fighting in widely separated mines that differ greatly in underground conditions and range from anthracite to lignite mines. Suggests means to prevent mine fires. 40 cents.

ASH, S. H., and FELEGY, E. W. Analyses of Complex Mixtures of Gases. Application to Control and Extinguish Fires and to Prevent Explosions in Mines, Tunnels, and Hazardous Industrial Processes. B. 471, 1948, 202 pp. Describes methods for utilizing analyses of complex gas mixtures as a basis for establishing safe procedures for preventing gaseous explosions and in controlling and extinguishing fires in mines, tunnels, and industrial plants. Includes formulas and explanations, graphs, and data relating to explosibility factors applied to complex mixtures of gases consisting of carbon monoxide, methane, hydrogen, ethylene, propylene, carbon dioxide, nitrogen, and air. 75 cents.

BUREAU OF MINES. American Standard Safety Code for Installing and Using Electrical Equipment in and About Coal Mines. (Revision of American Standard Safety Rules for Installing and Using Electrical Equipment in Coal Mines, M2-126.) B. 514, 1952, 28 pp. This bulletin, a revision of technical paper 402, Safety Rules for Installing and Using Electrical Equipment in Coal Mines, contains the American Standards Association's safety code for installing and using electrical equipment in and about coal mines, including requirements designed to minimize hazards resulting from the use of electrically operated equipment introduced into coal-mine practice in recent years. 20 cents.

Miners' Circulars

FORBES, J. J., and GROVE, G. W. Protection Against Mine Gases, Revised 1948. M. C. 35, 1948, 58 pp. Third of series of Miners' Circulars designed to be used in course of training that will prepare mine officials to organize men for mine rescue and recovery work. Discusses the erection of barricades during mine fires or following mine explosions, the construction of refuge chambers, the carbon monoxide self-rescuer, gas masks, oxygen breathing apparatus, and resuscitation. Its object is to acquaint men thoroughly with the various methods and devices used for protection against mine gases. 20 cents.

__________. Procedure in Sealing and Unsealing Mine Fires and in Recovery Operations Following Mine Explosions, Revised May 1948. M. C. 36, 1948, 84 pp. Last of series of four Miners' Circulars to be used in a course of training that will prepare mine officials to organize men for rescue and recovery work. Discusses organization, equipment and materials, and procedure in fighting, sealing, and unsealing mine fires and in recovery operations following explosions. Also includes practice problem for recovery procedure. Although data relate primarily to comparatively thin or medium-thick coal beds with little if any pitch, it is believed that procedure for sealing and unsealing mines, together with principles and technique of identifying fire gases, is applicable, with modifications in some instances, to metal mines and coal beds whether thick or thin and with varying pitches. 30 cents.

HARRINGTON, D., and FENE, W. J. Barricading as a Life-Saving Measure Following Mine Fires and Explosions. Revised December 1946. M. C. 42, 1948, 80 pp. Shows how miners trapped in a mine by an explosion or a fire may escape death by sealing themselves behind well-located and well-constructed barricades, bulkheads, or stoppings. In 1923, Miners' Circular 25 was issued, giving information on barricading done before that date. (Out of print.)

BUREAU OF MINES. Explosions and Fires in Bituminous-Coal Mines. Coal-Mine Accident-Prevention Course - Section 4. M. C. 50, 1946, 107 pp. Fourth in series of miners' circulars covering various phases of accident prevention in bituminous-coal mines designed to aid mine operators and officials in charge of training programs at mines. Lists factors responsible for mine fires and explosions, describes methods for preventing these disasters, and outlines topics for discussion in training classes. Illustrations of instruments used for detecting gas and testing velocity of air in a mine, references, and a bibliography are included. 30 cents.

Information Circulars

HARRINGTON, D., and VON BERNEWITZ, M. W. Saving Life by Barricading in Mines and Tunnels at Times of Disaster. I. C. 6701, 1933, 5 pp. Reviews instances in which lives have been saved by barricading and gives instructions as to methods of erecting such safeguards in various localities.

GRIFFITH, F. E., GLEIM, E. J., ARTZ, R. T., and HARRINGTON, D. Prevention of Fires Caused by Electric Arcs and Sparks from Trolley Wires. I. C. 7302, 1944, 10 pp. Suggests ways to minimize and prevent dangerous electric arcs and sparks, particularly those resulting from bare trolley circuits.

WESTFIELD, JAMES, BRUMBAUGH, H. C., and WHITTAKER, R. W. Extinguishing Fire with Carbon Dioxide in the Valier Mine, Valier Coal Co., Valier, Franklin County, Ill. I. C. 7563, 1950, 10 pp. Describes the sealing off of a fire in an Illinois coal mine and the successful use of carbon dioxide gas to extinguish it. Includes analyses of mine-air samples taken at regular intervals in the fire vicinity.

GALLAGHER, F. J. Minimizing Fire Hazards in Coal Mines by Proper Circuit-Breaker Protection of 250/275-Volt Direct-Current Systems. I. C. 7624, 1951, 11 pp. Some serious fires have occurred in bituminous-coal mines because of short circuits on direct-current power systems that do not have adequate circuit-breaker protection. Results of tests made in four coal mines on the effectiveness of circuit-breaker protection on 250/275-volt direct-current systems are given.

Report of Investigations

NAGY, JOHN, HARTMANN, IRVING, and HOWARTH, H. C. Tests on the Control of Coal-Mine Fires in the Experimental Coal Mine. R. I. 4685, 1950, 14 pp. Gives results of tests conducted in Experimental coal mine at Bruceton, Pa., to study some of the factors that should be considered in fighting mine fires and to obtain data on effectiveness of different types of extinguishing agents.